Dynamic of China's cultivated land and landcover changes of its typical regions based on remote sensing data

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Abstract: Using the multi-temporal Landsat data and survey data of national resources, the authors studied the dynamics of cultivated land and landcover changes of typical ecological regions in China. The results of investigation showed that the whole distribution of the cultivated land shifted to Northeast and Northwest China, and as a result, the ecological quality of cultivated land dropped down. The seacoast and cultivated land in the area of Yellow River Mouth expanded by an increasing rate of 0.73 $km \cdot a^{-1}$, with a depositing rate of 2.1 $km \cdot a^{-1}$. The desertification area of the dynamic of Horqin Sandy Land increased from 60.02% of the total land area in1970s to 64.82% in1980s but decreased to 54.90% in early 1990s. As to the change of North Tibet lakes, the water area of the Namu Lake decreased by 38.58 km^2 from year 1970 to 1988, with a decreasing rate of 2.14 $km^2 \cdot a^{-1}$.
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Introduction

Human activities induced landuse and landcover changes have become truly global in scale (Turner *et al.*, 1994; Zuidema *et al.*, 1994; IPCC 1996; Remankutty *et al.*1998). Better understanding current situation and mechanism of such changes are essential, which has significant impact on climate, biogeochemistry, ecosystem, and social economy (IGBP 990; IPCC 1996; Bonan 1997; Stohlgren *et al.* 1998; Karl *et al.* 1999; Houghton *et al.* 1999). China is the largest developing country in the world, and its arid and semi-arid regions cover 53.0% of total state area. With the development of economy and expanding of urban and industrial land, the cultivated land of China has reduced significantly, but population increased year by year (Chen 1997), which increased pressure on the cultivated land to produce more food (IPCC 1996). Thus, it is necessary to analyze landuse/cover change in China, and to pay more attention to the future trend of landuse /cover change in China.

Today, the progress of science and technology has provided the capability to study landuse, landcover, and environmental changes in large scale (Mathews 1983; Townshend *et al.* 1991; Brown *et al.* 1993). The remote sensing and GIS techniques have widely been used for monitoring global environment, landuse and landcover changes (Justice *et al.* 1985; Los *et al.* 1994; DeFries *et al.* 1994; Running *et al.*, 1995; Loverland *et al.* 2000). In this study, we used the remote sensing information and other survey of national land resources to study dynamics of China's cultivated land and landcover changes of its typical regions.

Method

In order to study the landuse/cover change in the period of 2-3 years, a project concerning the landuse/cover change has been performed in China since 1992 (Liu 1996). The Landsat TM (Thematic Mapper) images acquired around 1990 acted as main remote sensing data source. The interpretation mapping scales in the eastern China and in the western China are 1 : 250 000 and 1 : 500 000 separately.

The TM image combining digital data of visible and near infrared channels shows difference vegetation coverage, and can be used to landcover classification. In the TM bands, 2, 3, 4, 5 have capability for plant and soil detection (Mulders 1993):

band 2 (520-600 nm) for health plant and water.

band 3 (600-690 nm) for species plant and vegetation cover.

band 4 (760-900 nm) for biomass, water etc.

band 5 (1550- 1750nm) for soil moisture and plant mois-

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moisture.

Band 6 and 7 are located near to the water absorption band at 1 900 nm and consequently show the effect of absorption by water. The TM band rations 2/1, 3/1, 4/1, 4/2, and 4/3 are band transformations for discriminating soil and vegetation. After digitizing the landuse maps, basic geographic unit and administrative division separately, an integrated landuse and environmental background information systems of whole country were established. In the typical areas, multi-temporal Landsat data (TM or MSS image films) in 1970's, 1980's, and 1990's were used to carry out landuse and landcover changes such as urban growth, cultivated land reduction, water body change, desertification, afforestation and deforestation, etc (Wang, 1995).

Results and discussion

The changing situation of China's cultivated land resources in late ten years

With the continuously deepening of the reform and opening policy in China, the expansion of construction land results in the changes of the cultivated land resources. This situation catches the attention of the State Council and the local governments. In order to observe the changing situation of China's cultivated land resources in late ten years, we compared the research result of the remote sensing macro-investigation with the data which was obtained from the survey of national land resources (1:500 000) at the begin of 1980s. The 1980s' data was the gross area of cultivated land including the ridges between fields, small roads and irrigation ditches. It was comparable with the area of cultivated land achieved by extracting the small surface features sampled by mating the images from earth observation satellite with the airborne photo at about 1:30000 scale. The conclusion is drawn as follows after analyzing the data.

The total area of cultivated land in China decreased in recent ten years.

The national cultivated land resource in China (except Taiwan) was 1.397×10^8 hm^2 in 1985, but it was dropped to 1.373×10^8 hm^2 at this investigation. It showed that the total area of cultivated land was slightly dropped in recent ten years and that the amount of cultivated land in some of the remote border provinces was equivalent to that dropped out in some eastern districts of China.

Cultivated land area was increased in Northeast China.

In the typical area of Sanjiang Plain in Northeast China, where is under the dynamic monitor, the cultivated land increased to 704.62 km^2 in 1991, making up 61.45 % of the total area; while the cultivated land was 205.10 km^2 in 1985, making up 17.08% of the total area. The cultivated land increased by 44.37% from year 1985 to 1991.

The area of grassland decreased from 25.41% in 1985 to 1.63% in 1991 in Sanjiang Plain, with a decreasing rate of 23.78%. The swampland was 603 km^2 in 1985, making 32.23% of the total area, but it decreased to 413.47 km^2 in 1991, accounted for 22.15% of the total area. All these data showed that the cultivated land increased but the grassland decreased.

The update remote sensing data showed that the trend of the cultivating movement was out of control, and becoming more and more violently in the Northeast China Plain. Owing to the cultivated lands are located in fragile ecological region (Zhang *et al.* 1997), before cultivated, these lands belong to valuable grassland and wetland. However, after cultivated, the negative influence of the cultivating is difficult to be estimated.

The whole distribution of the cultivated land moved to northeast and northwest China, with the result that the ecological quality dropped down.

According to the analysis of the background quality assessment of the ecological environment in 19 provinces of China, the cultivated land decreased by 5.33×10^6 hm^2 within ten years. The decreased cultivated land was concentrated in the southeastern China and coast zone of China, these cultivated lands were of one or two class land; While the cultivated land increased to 6.6×10^6 hm^2, these land were concentrated in the fragile ecosystem with poor water and heat conditions, such as Xinjiang, Inner Mongolia, Heilongjiang, Liaoning, and Jilin provinces etc. The majority of the increased cultivated land was of three or four class land except a few parts of good ecological condition. That is to say, although the decreased area of cultivated land was not noticeably, the background quality of ecological environment of cultivated land decreased by two or three class due to the whole distribution of the cultivated land moving to the Northwest and Northeast China.

The change of the seacoast and cultivated land in Yellow River Mouth

Landcover change in the river mouth affects its discharge and brings not only flood but also hard conditions to get agricultural and urban water supply. Sediment deposition at the Yellow River Mouth is a main reason for repeated flooding at nearby cities (Li 2000). Thus, to examine the landcover change in Yellow River Mouth using satellite data and hydrological data is essential. The Yellow River Mouth is located at the projecting part between Bo Sea and Laizhou Gay (118°00′~119°19′ E, 37°18′~38°11′ N), with total area of 1 106.86 km^2. Climalogically, it belongs to temperature humid climate area, with an annual total precipitation of 594.3 mm, potential evaporation of 2 094.4 mm, annual mean temperature of 12.4℃, and a frost free period of 218 days. The area of epeirogenic land was 3 861 km^2 from 1855 to 1991. The average rate of epeirogenic land, calculated by the 136 years of walking river, was 28.4 $km^2 \cdot a^{-1}$. The length of the coastline was 145.8 km in 1855, while it increased to 233.8 km in 1975. The increasing coastline was 88 km, thus the rate of increasing was 0.73

km•a^{-1}. The length of coastline increased by 34 km from 1975 to 1991 and the total length of the coastline reached 267.8 km, with an increasing rate of 2.1 km•a^{-1}. The deposit extends forward by 33.75 km from 1975 to 1991, with a depositing rate of 2.1 km•a^{-1}. The area of the main cities and habitant locations was 31 km^2 in 1983, and it was 83 km^2 in 1991, increased by 52 km^2. The city's land was increased by 6.5 km^2•a^{-1} by means of cultivating the barren land.

The desertification dynamic in Horqin Sandy Land

The 1992 UN Conference on Environment and Development held in Rro de Janeiro, defined desertification as: " the land degradation in arid, semiarid, and dry sub-humid areas resulting from various factors including climate variations and human activities" (UNEP 1992; Hulme *et al.* 1993; Puigdefabregas 1995).

The desert areas distribute in a wide belt from Northeast China to Northwest China. The desertication process is serious and develops in an accelerating speed in China, caused mainly by natural wind and water erosion, salinzation, and excessive economic activities. The desert and desertification areas amount to 1 644 000 km^2, and the area of potential desertification land is 190 200 km^2 (Ci 1995).

We selected Horqin Sandy Land (118°35′~123°30′ E, 42°41′~45°15′ N) as a typical region for studying desertification dynamic. Geomorphologically, Horqin Sandy Land is in the transitional zone from Mongolia plateau to Northeast plain; and climatologically, it has the characteristics of the overlapping zone of subhumid and semiarid areas (Liu *et al.* 1996). The expansion of desertification in Horqin Sand Land was the result of the interactions of droughts strong and frequent windblown, and the unsuitable socio-economic activities (Dong *et al.* 1994; Liu *et al.* 1996; Zhang *et al.* 1998). The investigation showed that the desertification area in Horqin Sandy Land increased from 60.02% of the total land area in1970s to 64.82% in1980s but decreased to 54.90% in early 90s.

Horqin Sandy Land consists of six Counties. Kulun and Naiman counties are located in south high-terrace hill with chestnut soil and cinnamon soil. During 1980s to 1990s, the population density in Kulun County was maintained at 35 persons/km^2, and the population pressure was not serious. In the ten years, the cultivated area decreased by 4.65%, forest decreased by 15.97%, but grassland increased by 19.8%. In those increasing grassland area, the high coverage one occupies by 46.22%, low and middle coverage ones are 20.8%, and sandy and desert are 6.37%; the desertification area at potential risk increased by 23.58%. In Naiman County, population growth rate was also not obvious from 1980s to 1990s, but cultivated land was increased by 16.83% in ten years, forest was decreased by 16.4%, and grassland was increased by 3.41%.

The desertification area at potential risk was decreased by 8.88%. For these two counties, at present, the most important thing is to give the energetic support should be given to planting glass and tree, because they are located in south of Horqin Sandy Land, in which the temperature and moisture conditions are better than that in others desertification area of China. So long as rational utilize land resource, the desertification process might be controlled in this region.

The population growth rate was not obvious in Kezuohou County. The investigation presented that the cultivated land decreased by 6.13% from 1980s to 1990s, forest area decreased by 4.5%, and grassland area increased by 28.17%, in which, the high coverage one only accounted for 0.19%; middle and low coverage ones took up 74.11%. In this County, even if the increasing population was not clear in last decade, however, because of the over-grazing, over-cultivation and undue collection of fuel woods, the reduction of grassland cover was promoted. Thus, desertification area at potential risk was increased from 84.2% in 1980s to 91.32% in 1990s. Above-mentioned results recommend that landuse orientation should be readjusted in Kezuohou County; grassland or forage-farm should be encouraged for replacing the wild cultivation on steppe. We should make effective rotation grazing system and establish windbreak and sand break to protect forage farms and farmland. In that case, the desertification might be controlled and the degraded ecological environment will be restored in these regions.

The recent change of the north Tibet lakes

Qinghai-Xizang plateau (75°30′~103°30′ E, 28°00′-41°30′ N) is the Third Polar Region recognized by the whole world, where is a very special natural geographic unit, and human activities dealt little with natural resources of this area. The climate change directly influences the movement of glacier and the level of the lake water (Zou *et al.* 1997).

The series of North-Tibet lakes refers to the lakes lying in the North Tibet. The total area of the lakes is 21 396 km^2, making up 88.5% of the total lake area of Tibet, or more than 25% of the total lake area of China. North Tibet is one of the biggest areas of lake distribution in China. The result of remote sensing investigation showed the trend of the water area of the Namu Lake changing was decreasing nearly ten years. The area of the water decreased by 38.58 km^2 from year 1970 to 1988, with a decreasing rate of 2.14 km^2•a^{-1}.

Owing to the global warming, the Namu Lake and other lake groups of North-Tibet Plateau evaporated rapidly, and the glacier draws back, so that less of melting snow water pour into the lakes, thus the levels of the lakes fall down.

Summary and conclusion

In the last two decades, China has a rapid development in economy. At present, it is obvious that China is confronting with the seriousness of resources and environment

problems caused by human activities and the change of natural conditions. Therefore, it is essential for Chinese government to attach more importance to the study of land-use/cover change and ecological environment, so as to adjust the policy of economic development in the process of modernization in the country.

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